

No. 3—Notes on Several Species of the Earthworm Genus

DIPLOCARDIA Garman 1888

By G. E. GATES

The material on which this contribution is based comprises miscellaneous lots recently received for identification. All of them are of special interest as little is known about any of these native earthworms of a genus restricted to United States and Mexico.

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DIPLOCARDIA ALBA Gates 1943

Subspecies *mexicana* subsp. n. (?)

In soil with chrysanthemum plant from Mexico arriving at Gateway Bridge, Brownsville, Texas, 2/20/50, 1 clitellate specimen in three pieces. (A posterior fragment in the same tube presumably is of the same species.)

External characteristics. Length, *ca.* 60 mm. Diameter, *ca.* 3 mm. Segments, *ca.* 136. Prostomium slightly proepilobous. Clitellum slightly tumescent, dark brownish, annular, extending from 12/13 to 18/19 but lacking ventrally on xviii.

Spermathecal pores in *AB*, slightly nearer equators than intersegmental furrows, on viii/aq and ix/pq. A ventral tumescence reaches laterally on each side to *C* on viii and ix.

Seminal grooves nearly straight, in *AB*, each on a longitudinally placed, parietal tumescence that extends from *A* to *mBC*. A deep transverse furrow, apparently slightly postsetal (19/20 unrecognizable in *BB*), ends on each side at *C* on xix.

Internal anatomy. Septum 5/6 membranous, 6/7-11/12 mus-

cular. Oesophagus with several low but rather thick longitudinal ridges on inner wall in xii-xiv. Intestinal origin in xvii. Typhlosole small, lamelliform, beginning in xx.

Prostates flattened, each in a U-shape. Prostatic ducts slender, almost straight, passing into parietes about at *B*. A penisetal follicle is slightly protuberant into the coelom near *A* in xviii and xx.

Spermathecal duct longer than the ampulla, an ental portion rather barrel-shaped, gradually narrowing ectally and quite slender in the parietes. Diverticulum flattened, vertical, ventrally directed, on anterior (?) face of ental part of duct.

Follicles of *a* and *b* setae of viii and ix are enlarged and slightly protuberant into coelomic cavity.

Life history. Male funnels and seminal chambers of spermathecal diverticula are iridescent. Reproduction obviously is sexual (biparental). The breeding season just as obviously includes February.

Remarks. The anatomy, unless otherwise indicated above, is as in *alba* except for location of the first dorsal pore (not determinable) and the copulatory and penial setae (not examined).

D. alba is known only from a series of 49 specimens collected at Fort Myers, Florida. Spermathecal pores, according to that sample are migrating posteriorly from the primitive location on intersegmental furrows 7/8 and 8/9. The posterior pores have moved further than the other pair but had only just reached the equator of ix in one worm. Posterior pores already are definitely postequatorial in the Mexican specimen but the intestinal origin still is in xvii (rather than xviii, Fort Myers). The only other difference recognized is extension of the clitellum over xviii in the Mexican subspecies.

For each of the two detected cases (cf. p. 236) of accidental transportation of diplocardias there must have been very many others, some even to foreign lands. Successful colonizations (after accidental introductions) apparently are not to be expected outside of the United States and Mexico but cannot yet be ruled out within the generic range.

DIPLOCARDIA COMMUNIS Garman 1888

Chapel Hill, North Carolina, April 19, 1932, 2 clitellate specimens.

J. M. Valentine per Dr. G. E. Pickford.

External characteristics. Length, 120 mm. Diameter (through clitellum), 6 mm. Segments, 149, 191. Unpigmented (formalin preservation). Prostomium epilobous, *ca.* $\frac{1}{2}$, tongue possibly closed (? peristomium deeply grooved all around). Secondary annulations; one postsetal secondary furrow per segment from iv back and one presetal from v or vi, posteriorly tertiary furrows may be present but often incomplete. Setae begin on ii; *AB ca.*—or a trifle $< CD$, *BC < AA*, *DD ca.*— $\frac{1}{2}C$. First dorsal pore on 8/9 (1), 9/10 (1). Clitellum markedly tumescent, dark red, saddle-shaped, reaching ventrally nearly to *A* or *B*, on xii-xix but not as thick on the first and last segments. Epidermis thickened and red on the presetal portion of xiv in *AA*.

Spermathecal pores on vii-ix, slightly behind intersegmental furrows, on or just lateral to *A*, at tips of slight tumescences projecting anteriorly in a somewhat pointed and conical fashion over the intersegmental furrows. Female pores probably antero-medial to *a* and nearer to that seta than to each other. No specially demarcated male field. Seminal grooves between equators of xviii and xx, slightly concave laterally, deep and wide, margins quite tumescent and especially at the ends. Male pores not recognized but possibly on very small white tubercles in the seminal grooves just behind 18/19.

Genital markings paired, transversely elliptical, reaching slightly beyond both *A* and *B*, possibly primarily postsetal but definitely crossing intersegmental furrows. Each marking has a distinct greyish translucent center which may be differentiated into outer and inner zones, and an opaque, tumescent, marginal band. Locations are as follows: on 10/11-12/13, 17/18, 20/21-21/22 (1), 10/11-11/12, 22/23-24/25 (1).

Internal anatomy. Septum 5/6 membranous, 6/7-10/11 thickly muscular.

Gizzards in v-vi (2). Oesophagus with numerous, low, blood-filled, irregularly zigzagged, longitudinal ridges which may in part be constricted into villiform protuberances on the inner wall in x-xv. Valve in xvi and anterior half of xvii. Intestinal

origin in xvii (2) but inner face of gut from xvii through xx or xxiii has a distinctly different appearance from that of the remaining part of the tube and the coelomic face is whitish. Typhlosole begins in xix or xx and is rather low but lamelliform to *ca.* lxx from whence posteriorly it is represented only by a flat and strap-shaped thickening at mD that shortly disappears.

Dorsal blood vessel double from vii to the hind end. Behind xxiii disjunct midsegmental portions are in contact and may be rather short. Supra-oesophageal trunk recognizable only in x-xii and anteriorly in xiii. No subneural trunk. Hearts of x-xii apparently latero-oesophageal but the dorsal bifurcations are filamentous. Last hearts in xii (2). Paired preseptal branches from the dorsal vessel present from xiv posteriorly, each vessel long, looped, covered with so much chloragogen as to be quite conspicuous.

Nephridia small but reach laterally to or beyond *D*, avesculate, ducts slender and gradually narrowed as they pass dorsally, disappearing from sight and possibly into the parietes well above *D*. Each tubule in the clitellar segments is in three distinct clusters of short loops connected only, so far as can be seen, by a delicate filament which is assumed to provide continuity between the clusters.

Brain apparently in ii, posterior margin concave.

Prostates fairly large and extending through part or all of xvii-xxiv. Prostatic duct 3 + mm. long, looped. Vasa deferentia are recognizable from the interior and can be traced lateral to anterior prostatic ducts and into xix where they disappear into the body wall. Penisetal follicles very close together ectally and apparently passing into parietes on anterior faces of prostatic ducts, the *a* and *b* follicles separated from each other only by a delicate strand of tissue. Each follicle contains one functional seta and a very short reserve (tip portion only). Size; *ca.* 1.1 mm. long \times 0.02 mm. thick near base. Shaft very gradually narrowed ectally, only slightly curved or arced. Tip may be flattened slightly on two sides but ectal margin is rounded not truncate. Ornamentation of several circles (complete?) or shorter transverse ridges or rows of small teeth.

Spermathecae may reach up to level of dorsal face of gut, the size decreasing anteriorly. Duct much shorter than the slightly

thicker and usually rather sausage-shaped ampulla, wall rather thick, lumen slit-like in transverse section. Diverticulum sessile on lateral face of duct about midway between ectal and ental ends or even a trifle more ventral, spheroidal, sausage-shaped, or with several marginal incisions. Follicles of ventral setae of vi-x do not project into the coelom. Oviducts not widened, gradually narrowing from 13/14.

Genital markings apparently are areas of epidermal thickening and modification only as no glandular material is recognizable in the muscular layers.

Life history. The clitellum may well have reached maximum tumescence. Brilliant iridescence on male funnels and in spermathecal diverticula shows that sperm had been produced and received in copulation. Reproduction clearly is biparental and a spring breeding season is indicated.

Remarks. The spermathecal pores in *communis*, according to Garman, are "at the anterior edge of" vii-ix, presumably meaning thereby just behind the intersegmental furrows as in the Carolina worms. Spermathecal pores of *Perichaeta* sp. (= *Pheretima diffringens*) were said, in the same contribution (Garman, 1888, p. 74), to be "at the anterior edge" of vi-ix. In this species however the apertures are actually on the intersegmental furrows. It is not therefore certain that the locations in the types of *communis* were intra-segmental. Intersegmental locations are listed for *communis* by Smith (1915), Olson (1928 and 1936) and Causey (1952) but segmental locations were recorded by Eisen (1900). The latter not only had Illinois material that may have been topotypical but did distinguish, in his specific diagnoses, between the two types of locations (cf. p. 242).

The various differences between the Carolina worms and those studied by Garman and Eisen are all small. What importance is to be attached to such differences awaits determination of variation in the type region (locality not precisely stated) and/or elsewhere.

DIPLOCARDIA FUSCA Gates 1943

Dallas, Texas, February 1954, 1 clitellate specimen. Ottys Sanders.

(A number of juvenile and acitellate specimens collected in the same region, in spring, summer and early fall, also have been

supplied by Mr. Sanders at various times from 1930 to date.)
Victoria, Texas, on ground under log in river bottom, Jan. 5, 1915,
1 acitellate specimen. J. D. Mitchell. (U. S. Nat. Mus. No.
57889.)

External characteristics. Size, 220 x 8 mm. (strongly contracted clitellate worm), to 380 x 8 mm. (other specimens, also strongly contracted). Segments, 311 (clitellate worm). Pigmentation especially dense in the dorsum of xi-xii, rather dense in xxi but elsewhere sparse and unevenly deposited or not certainly distinguishable from alcoholic browning. Setae unrecognizable on preclitellar segments, elsewhere *AB* appears to be smaller than *CD*. The first dorsal pore is on 11/12 (clitellate worm), 10/11 (several others). The clitellum is markedly tumescent, the dorsal pores occluded and intersegmental furrows only faintly indicated (setae?), gradually becoming thinner ventrally and possibly lacking in *AA* on xiii-xvii, lacking ventrally on xviii-xx, bounded anteroposteriorly by 12/13 and 20/21.

Female pores are anteromedian to *a* and nearer those setae than to each other. Male pores were not recognizable, even after tracing the male ducts through the parietes but must be in the seminal grooves and near the equator of xix. Genital markings lacking.

Internal anatomy. Septum 5/6 is muscular. Intestinal origin in xvii (clitellate worm and several others). The typhlosole begins in region of xxiv, is 1½ mm. high, lamelliform, and ends abruptly in cexxxv (of 311 segments). The dorsal blood vessel is double from vii-xlix, single in vi, double in v, thence anteriorly empty and unrecognizable.

Male funnels, in x-xi, are large, plicate, only slightly iridescent. Seminal vesicles are medium-sized. Prostates are rather small and confined to one or two segments. Penisetal follicles are unrecognizable in xviii and xx though gaps in the longitudinal musculature are obvious, not only on the median side of each prostatic duct (*b*) but also further mesially (*a*). The *a* and *b* follicles of xviii and xx (but not those of xix) were found after removal of the longitudinal musculature. These follicles are a trifle smaller than those of xxi and xvii. Setae are slightly sigmoid though a nodule is almost unrecognizable. The tip is ornamented with about 15 quite irregular circles of very small

teeth, irregularly and frequently interrupted. No follicles are protuberant from the parietes in the spermathecal region.

The spermathecal duct is slender in the parietes, gradually widened entally, as also its lumen, but there is no definite demarcation of ampulla recognizable either externally or internally. The diverticulum is a vertical row of four or five seminal chambers of varying size, the ectalmost the largest. The diverticular stalk is very short and slender, from proximal face of diverticulum slightly above midpoint. Above the stalk the diverticulum is adherent to the main axis but is free below. The material within the diverticulum has a slight iridescence and is so tough that it can be dissected out intact as a "cast" of the stalk-diverticulum lumen.

Juveniles. The *a* and *b* setae are present in xviii and xx but are lacking in xix.

Life history. Reproduction apparently is sexual (biparental) and possibly in the winter as the only clitellate specimen that has been available hitherto was obtained in February. One other clitellate worm was obtained by Mr. Sanders in the same month (but it died before preservation). Every one of a number of specimens he forwarded at various times from 1930 on, except for the one described above, has been juvenile or acitellate. These, as noted above, were secured in spring, summer or early fall. Several of the worms supplied by Mr. Sanders probably were postsexual acitellates but it is now impossible to say more than that as most of the records were destroyed in Burma during World War II.

Habits. Worms of this species, according to Mr. Sanders, cast on the surface of the ground, especially in the spring.

Castings are described by Mr. Sanders (*in lit.*) as follows: "The larger mounds are about 10 cm. in diameter and 2.5 cm. in height. The mound (pl.) does not rise to a sharp apex but a broader one crowned with coarse pellets. Mounds usually are about six inches apart when clustered but may be even closer or several feet away from each other. Castings are distinguishable from those of ants by the size of the pellets. (The size of the earthworm may be judged, to some extent, by the size of the castings.) After pouring a vermicide on the castings worms emerge six inches to farther away from the mound." The cast-

ings sent by Mr. Sanders show that intestinal contents are deposited in piles of long cords *ca* 2 mm. thick (dried) that are slightly constricted at irregular intervals of 3-5 mm. Many small pieces now are discrete but probably were broken off at the constrictions. Shortly after submergence in water the castings had disintegrated and the mud had settled to the bottom.

Habitats. Agricultural soil. Soil (limestone based, blackland soil) of lawns and other grassy spots (Mr. Sanders). Under logs of river bottoms.

Distribution. Fort Worth, Dallas (alt. 512 ft.), Victoria, and possibly in the hills at Palo Pinto some 70 miles east of Dallas. The species, according to Mr. Sanders, "is widely distributed in the Dallas area."

Remarks. The description above, except as otherwise indicated, refers to the clitellate worm which is the only one that has been available in that condition for study.

Spermathecal locations in this species may have resulted from forward displacement of the ancestral pairs that originally opened externally on 7/8-8/9. Alternatively the quadrithecal condition could have been derived from a sexthecal ancestor (possibly less remote) by elimination of the posterior pair of spermathecae.

A large Texan species which may well be *D. fusca* is frequently used as bait in that state by anglers. These worms, according to Dr. C. A. Moyer, are "brittle, stand high temperature, give off a sticky secretion, make good bait for catfish and white perch but are not taken by the blue-gilled sunfish." The sticky secretion, according to Mr. Sanders (*in lit.*) "has quite an odor and is very difficult to wash off one's hands and the earthworm secretes it most profusely."

DIPLOCARDIA INVECTA n. sp.

In soil around geranium plant arriving from Mexico at Hidalgo, Texas, 5/27/54, 3 a clitellate and 6 clitellate specimens.

External characteristics. Length, 55-63 mm. Diameter, 2-3 mm. Segments, 128, 130, 132, 133. Unpigmented, clitellum with a light yellowish or brownish appearance. Secondary annulation indistinct, behind iv or v comprising one presetal and one

postsetal furrow per segment. Prostomium prolobous and demarcated by a posterior furrow (1), slightly epilobous but without a posterior furrow to tanylobous (5). Setae are retracted, probably small, but begin on ii; $AB < CD < BC < AA$, $DD < ca. = 1\frac{1}{2}C$. First dorsal pore on 7/8 (5), 8/9 (3), 9/10 (1). Clitellum annular, between 12/13 and 18/19 (4), reaching only part way onto xviii (1), between 13/14 and 17/18 (1), dorsal pores occluded, intersegmental furrows faintly indicated or unrecognizable, setae present.

Quadrithecal, pores at or just lateral to *A* and slightly behind 7/8 and 8/9. Female pores apparently both present (5) and slightly anteromedian to *a*. Prostatic pores equatorial on xviii and xx, about as far lateral to the aperture of the *b* follicle as the latter is from that of the *a* follicle, both apertures more closely paired than on other segments. Ventral setae of xix apparently lacking and no follicle apertures recognizable. Male field not specially demarcated in any way. Seminal furrows indistinct and rather indefinite, in some worms represented only by lines or bands of greyish translucence always concave laterally.

Genital markings paired, centered about at *A* but not reaching mV, transversely elliptical, postsetal; on xiii (8), xvii (8), possibly also on xx (3?). Markings are tumescent except on one worm where they are represented only by a special whitening of the epidermis. There is no distinct demarcation of a central area and marginal rim as in so many oriental species but on two worms a fine, greyish translucent circle enclosing an opaque (rather than translucent area) is recognizable on each tumescence.

Internal anatomy. Septa 6/7-8/9 are somewhat thickened.

Gizzards small, in v-vi (6). Oesophagus highly vascular and widened in ix or x to xii or xiii, with very low longitudinal ridges on the inner wall, valvular through xvi. Intestinal origin in xvii (6), apparently just behind 16/17. The typhlosole is lamelliform but quite low. It begins in xxi (1), xxii (2), xxiii (2), or xxiv (1) and ends in c (1) or civ (1). An apparent slight thickening of a middle or even a posterior portion may be an artifact resulting from a differential effect of the preservative.

The dorsal blood vessel is single throughout (6). The last

hearts are in xii (6). No subneural trunk (6). Nephridia are small, extending laterally on parietes slightly beyond *D*.

Holandric, seminal vesicles rather small, acinous, of a rather grey translucent appearance, in ix and xii (6). Prostates are rather short and small but not juvenile, confined to one or two segments, in the latter case xviii-xix and xx-xxi. The ducts are short and slender.

Spermathecae are small and beneath the gut. The diverticulum is a vertically placed row of three to five seminal chambers, with a very short and slender stalk from narrow proximal side to lateral face of duct, and with connective tissue passing from ventral end to posterior face of septum in front.

Life history. No spermatozoal iridescence was recognized on male funnels or in spermathecae of any of the six dissected worms. Prostates may be fully developed but seminal vesicles and spermathecae apparently are not. Clitellar tumescence could have been maximal only in one worm. Presumably age of reproduction had not yet been attained.

Remarks. Follicles of ventral setae of spermathecal and prostatic segments are unrecognizable in the coelomic cavities. Tips of ventral setae of xvii and xix are visible in the follicle apertures. Actual female pores were not seen, the sites indicated by slight depressions with very slight tumescent margins. Metamerism in region of xvii-xxi of one worm is abnormal.

D. invecta is distinguished from *alba* by the presence of genital markings, the simplex condition of the dorsal blood vessel, and the absence of hearts in xiii. With respect to the last two of these characteristics, *invecta* is less advanced than *alba*. Differences from *udei* are: fewer segments; more anterior location of first dorsal pore; slightly more anterior location of spermathecal pores; presence of genital markings in the clitellum; simplex condition of the dorsal trunk in the posterior portion of the body; absence of copulatory setae in viii-ix (or at least of large follicles protuberant into coelomic cavities) and absence of penisetal follicles in the same cavities. Additional differences may be recognizable when fully mature adults can be studied.

DIPLOCARDIA ORNATA Gates 1943

De Queen, Arkansas, 3 miles to the west, 4/27/52, 2 large juvenile

and 7 clitellate specimens. Five miles to the west, 3/30/52, 2 clitellate specimens. Mr. Ottys Sanders.

External characteristics. Size, 45-60 mm. x 2-3 mm. Segments, 114, 116 (March), 124 (last five regenerated?), 141, 146, 148, 150. Pigmentation unrecognizable, parietes translucent (alcoholic preservation). Prostomium, epilobous, *ca.* $\frac{1}{2}$ or less, tongue open (1), closed (5), pointed, bounding furrows meeting at mD well towards $\frac{1}{2}$. Setae begin on ii; $AB < CD < BC < AA$, $DD \text{ ca.} = \frac{1}{2}C$ or somewhat smaller (?). Nephropores slightly above *D* on clitellar segments, well dorsal on ii, not certainly recognizable elsewhere. First dorsal pore on 9/10 (2), 10/11 (1), 11/12 (3). Clitellum annular except on xiii and xviii, on xiii-xvii (1), xiii-xviii (7), xiv-xvii (1), possibly not developed to full anteroposterior extent on the two odd worms.

Spermathecal pores very small slits surrounded by annular tumescences, slightly behind intersegmental furrows and at or slightly lateral to *A*, on vii-ix. Female pores slightly antero-medial to *a* to which they are nearer than to each other, within a single transverse area of slight epidermal modification. Seminal grooves concave laterally, broad and deep, in *AB*, between equators of xviii and xx. Male pores presumably on very small conical protuberances in the seminal grooves just behind 18/19.

Genital markings rather indistinct, transversely elliptical, paired, centered about at *A*, on 17/18 (\pm), 16/17 and 17/18 (1).

Internal anatomy. Septa 5/6-6/7 membranous, funnel-shaped, in contact with the gizzards from which they can easily be pushed back; 7/8 transparent but with a slight sheen indicative of presence of muscular fibres; 8/9-10/11 muscular.

Gizzards large (relatively) and in v-vi (11). Oesophagus without especial local widenings, with some slight ridging of inner wall in x-xi or xii but none recognized in xiii; valvular in xvi (6), relaxed, filled with soil and of about the same diameter as in xiv-xv (3). Intestinal origin in xvii (11). Typhlosole begins in region of xix-xxi and is a rather low but still lamelliform ridge.

Dorsal blood vessel in simplex condition as far back as its character can be determined. Supra-oesophageal and extra-oesophageal trunks present though the former usually is empty, the latter median to the hearts. No subneural. Hearts of x-xii

apparently latero-oesophageal but the connectives to the dorsal trunk very delicate and colorless. Last hearts in xii (11).

Nephridia present from ii posteriorly, funnels of the anterior pair not found. Ducts of the anterior pair passing well dorsally. Nephridia seem to be rather small but reach somewhat beyond *D*. No vesicles recognizable.

Brain in ii, slightly bilobed, anterior margin straight, posterior margin with well marked concavity mesially. Nerve cord without marked muscularity in sheath.

Holandric; seminal vesicles acinous, in ix and xii. Prostates usually not confined to one segment, and may extend as far back as into xxiv; ducts slender, straight, *ca.* 1 mm. long, passing into parietes in the gap at *B*, in xviii and xx. A flat, strap-shaped muscle band is inserted on the parietes, in xviii and xx, lateral to *D*. From it there can be separated off, in favorable conditions, two follicles, one passing into the body wall on the anteromedian aspect of the prostatic duct, the other mesially but still lateral to *A*.

Ovaries conspicuous. Ovisacs lacking (? not found). Oviducts on emerging into xiv much swollen, then narrowed again within the parietes, the widened portion sausage-shaped, resting on the body wall, with the parietal continuation (at maximum development) passing down from the under side.

Spermathecae fairly large, reaching up to level of dorsal face of gut or long enough to do so, often flattened out on the parietes or passing through the neural arch of a septum into the preceding segment. Duct shorter than the ampulla which usually is only slightly thicker and sausage-shaped. Diverticulum vertical, sausage-shaped, leaf-shaped, a flattened disc of three or more round lobes, or of various other shapes, usually with a little connective tissue passing from a ventral portion to posterior face of septum in front. Stalk always short, slender, from an ental part to lateral (?) face of duct near ampulla. Contents of a sausage-shaped diverticulum obviously in a single mass that can be dissected out intact. Margins of other diverticula more or less deeply incised. Follicles of ventral setae of vii-ix usually do not protrude into the coelom. From a follicle of vii that did so, one seta, probably a reserve, was obtained. No ornamentation was recognized. The extreme tip was curved over to one

side more than would be expected in an ordinary sigmoid shaft.

Penial setae average about 1.1 mm. in length and 10μ in diameter at or near the ental end. The shaft is slightly arced, gradually narrowed ectally to 5μ or less. An ectal portion usually is deformed, bent, twisted, or wrinkled but occasionally is almost straight. The tip may be flattened on two opposite sides or not. The ectal end is never truncate but usually rounded and when flattened has an appearance of tapering more to a rather bluntly rounded point. The tip always appears to be complete in spite of deformation and is without a terminal filament which likewise is lacking in the very young reserve setae.

Juveniles. These two worms are of adult size but genital markings are unrecognizable. Seminal grooves are not visible but probably not because of condition. Setae and apertures of ventral follicles of xviii-xx are unrecognizable. Seminal vesicles are small or rudimentary, prostates restricted to xviii and xx, spermathecae only slightly protuberant into coelom. Ovaries are small. Oviducts are slightly thickened in one but not in the other worm. Male funnels quite without iridescence.

Abnormality. The clitellum is of maximal extent and possibly tumescence also on the two March worms (5-mile site) with only 114 and 116 segments. Ovaries are large, oviducts swollen, and spermathecae are of normal size but seminal vesicles and prostates are rudimentary. The prostatic glands are about as long as their ducts but even thinner and both are concealed from view beneath the nephridia. No iridescence on male funnels or in the spermathecal diverticula.

Life history. The worm with clitellum restricted to xiv-xvii may not be fully mature. Clitellar tumescence is not especially marked and is lacking in 4A. Seminal vesicles are rather small, like the prostates which are confined to xviii and xx-xxi. Spermathecal diverticula have no iridescence but small spots are recognizable on the male funnels which are not yet as large as in the other clitellate worms. By full maturity the clitellar tumescence might have extended through 4A as well as across xiii and xviii.

Male funnels and spermathecal diverticula of the other six clitellate April worms are iridescent, of considerable brilliance in several cases. The clitellum may well have reached maximal

tumescence on three or four specimens. Reproduction presumably is biparental and a spring breeding season is indicated for Arkansas. In Tennessee this species apparently breeds (also?) in the fall (Gates, 1943).

Remarks. These worms, probably contracted, were becoming brittle when studied and already were browned by the alcohol. Soaking in water released the cuticle but left intestinal tissue too gelatinous to trace the typhlosole posteriorly. Nephridia are soft, often more or less broken.

Spermathecal pores of the anterior pair may be even closer to the intersegmental furrow than those of the other two pairs and in one worm seemed to be almost on the furrow.

Nephrostomes also were not found for a number of segments behind i but nephridia from iii on through the clitellar region seem to be less well preserved than in ii.

These worms are referred to *ornata* in spite of differences involving prostomium, clitellum, etc., for geographical as well as morphological reasons. *D. singularis*, according to those who studied topotypical material, has its spermathecal pores on the intersegmental furrows.

DIPLOCARDIA RIPARIA Smith 1895

Warner (25 miles southeast of Muskogee), Oklahoma, in Dirty Creek bottoms, April 1954, 7 juvenile, 5 a clitellate, 1 clitellate and 1 postsexual (?) a clitellate specimens. Vera Lee Rounds. (U. S. Nat. Mus.)

Muskogee, Oklahoma, 1 juvenile, 1 early clitellate (?), 2 clitellate and 1 postsexual a clitellate (?) specimens. H. & R. earthworm farm per U. S. Nat. Mus. (These specimens probably were from the same site and same person as the first lot and were collected several weeks earlier.)

External characteristics. Length, 50 (smallest juvenile), 130-145 mm. (clitellate). Diameter, 3 (smallest juvenile), 6-8 mm. (clitellate). Segments, 146 (juvenile), 173, 179, 185(2), 194. Pigmentation brown, fairly dense in dorsum of first 12 or 13 segments, or also through xviii, xix or xx, gradually becoming more sparse posteriorly, apparently lacking in most of the intestinal region, obvious again in the last few segments except in regenerates (unpigmented). Pigment is however recognizable

under the binocular, throughout the intestinal region, in fine equatorial lines widened around apertures of setal follicles when continued ventrally. Secondary annulation is well marked, a postsetal secondary furrow present from iii or iv, a presetal furrow present from v or vi, and from vii posteriorly a tertiary furrow present (on dorsum only or all around) on the pre- and post-setal secondary annulus. Prostomium epilobous, *ca.* $\frac{1}{2}$, tongue closed.

Setae may be so deeply retracted as to be unrecognizable on anterior segments but begin in ii; $AB < CD$ especially anteriorly but difference is slight, $AA = BC$ or slightly unequal, DD *ca.* $= \frac{1}{2}C$. Nephropores (usually not certainly recognizable, all specimens strongly contracted), apparently at or near *D*. First dorsal pore on 11/12 or 12/13. Clitellum annular, but thinner in *AA*, between 12/13 and 18/19 (3), 19/20 (1), possibly reaching slightly onto xix (1), dorsal pores occluded, intersegmental furrows unrecognizable except ventrally (setae?).

Quadrithecal, pores slightly lateral to *A* and just behind 7/8 and 8/9. Female pores slightly anteromedian to *a* and much nearer *A* than to each other (4). Male and prostatic pores not certainly identified but probably in seminal furrows extending in *AB* between equators of xviii and xx.

Genital markings represented by raised, transversely elliptical, postsetal, paired areas of epidermal tumescence reaching nearly to mV and well into *BC*, on xvi-xvii (1), Rxvi, xvii, Rxx, xxi (1), xvii (1), xvii, xx and xxi (2), xvii, xx, xxi and xxii (1), xxi (1), xxi-xxii (1). Ventral setae of the segment usually are included in the marking but no demarcation into rim and central area has been recognizable.

Internal anatomy. Septum 5/6 thin, 6/7-9/10 thickly muscular, 10/11 and the next few septa muscular to slightly muscular.

Gizzards in v-vi (15). Oesophagus highly vascular and widened in xii, xii-xiii or xii-xiv, then gradually narrowing, valvular in posterior part of xvi and anteriorly in xvii. Shortly villiform or small, low ridge-like protuberances (transverse or longitudinal) present on inner wall but no definite calciferous lamellae. Intestinal origin posteriorly in xvii (14) or in xviii (1). The typhlosole which begins in xxii (2) or in region of xxiii-xxvi is lamelliform but certainly quite insignificant, unrecognizable

behind lxxiii (specimen of 185 segments).

The dorsal blood vessel is single throughout (13) or double (2) in some part of its length. Hearts of x-xiii latero-oesophageal, the last pair in xiii (15). Six pairs of vessels join the ventral trunk anterior to 6/7, the first two pairs very close together, the anteriormost passing dorsally along with circumpharyngeal nervous commissures and uniting behind the brain to form the dorsal trunk (3). No subneural.

Holandric, seminal vesicles medium-sized, in ix and xii (4). Prostates are fairly large, 10-20 mm. long, and may extend forward into xiv and back to xxvi though long enough to reach further in either direction. The small slit-like lumen is eccentrically but is unrecognizable entally in free-hand sections. Prostatic duct slender, 3-4 mm. long. Penisetal follicles attached to each other entally, divergent ectally, one passing into parietes on median face of prostatic duct, the other more mesially, definitely protuberant (though but shortly) into the coelomic cavities. Each contains one seta (no reserves found). Penial setae are *ca.* 1 mm. long, *ca.* 25 μ thick at widest, slightly bowed, tapering ectally to a sharp point. Ornamentation ectally of 15 to 20 quite irregular circles of fine teeth, frequently but irregularly interrupted. No setal follicles especially protuberant from parietes in spermathecal region.

Spermathecal duct longer than the ampulla, bulbous, with a slightly narrowed neck-region entally, gradually narrowed ectally and within the parietes. Lumen gradually widened entally or abruptly widened just below level of diverticular junction. Ampulla heart-shaped to ellipsoidal, slightly wider than thickest part of duct. Diverticulum short, vertical, with a very short and slender stalk from middle of proximal face to lateral face of widened portion of duct, with connective tissue passing directly to posterior face of septum in front. Seminal chambers 3-12 in a vertical row.

Juveniles. The small juvenile (50 x 3 mm.) has all four ventral setae of xix protuberant and in line with the same setae of other segments. Ventral setae of xviii and xx are retracted, follicle apertures approximated but those of the *b* setae displaced more than the others. Ventral setae of xix are still present and in the *A* and *B* ranks in the 100 mm. worm but appear to be

lacking (follicle apertures unrecognizable) on the larger juveniles. Prostates are only about one mm. long in the small juvenile and penisetal follicles are just protuberant beyond the parietes. All worms listed as juvenile have not yet developed seminal grooves.

Life history. Reproduction presumably is sexual, i.e., biparental and may take place, in Oklahoma, in winter and/or early spring. Individuals of this species may survive one breeding season to reproduce again after a period of sexual inactivity. One worm without trace of clitellar tumescence does have a dark brown coloration of the dorsum in xiii-xviii that is lacking both anteriorly and posteriorly. No spermatozoal iridescence was recognized on male funnels or in spermathecal seminal chambers but the seminal vesicles are dark, shrunken, and contain brown bodies (probably aggregates of disintegrated phagocytes and other debris). The mass within each spermathecal ampulla is dark brown peripherally and the contents of seminal chambers in the spermathecal diverticula are also brown. Prostates are yellowish or greyish and with an appearance as of a fine black dust deposited in crevices and irregularities. These conditions have not been seen in juveniles or worms that were becoming sexual and are thought to mark an advanced stage of postsexual regression. This part of the life history apparently has not been subjected to careful study in any species of earthworm. In various species of other genera the adults have been thought to die after the first period of reproduction.

Abnormality. The right seminal vesicle of xii had been herniated almost completely into xi in one worm.

Regeneration. Two unregenerate posterior amputees. Tail regenerates: of ca. 35 segments at 84/85, of 12 segments at 141/142, of ca. 16 segments (metameric abnormality proximally) at ca. 144/145 (metameric abnormalities in the intestinal region), of 12 and 15 segments at 142/143 (one of these regenerates with metameric anomalies proximally), of 14 segments at 174/175. The last 19 metameres of the 146-segment juvenile probably are regenerated. The small juvenile (50 x 3 mm.) has an old tail regenerate at 72/73 and a small, metamericly unsegmented, second regenerate (with terminal anus) at 97/98. Regenerates unpigmented.

Remarks. Setae are unrecognizable in the last few (5-6) segments of worms without amputation and posterior regeneration. Nephropores may however be recognizable.

Doubling of the dorsal blood vessel is limited to vi-xvii (1) or is represented only by midsegmental perforations (1), in xiii-xiv, xvii, xxi, xxiii-xxiv. The occurrence of this condition in but two of the fifteen dissected worms permits a guess that it is due to a mutation partially inhibiting dorsal union of paired embryonic anlage. If so, establishment of such a mutation has been involved in the evolution of various species of *Diplocardia* including the genotype.

This species was but briefly characterized by its author. Some additional information as to material from the same general Illinois locality (Havana) was later provided by Eisen (1900). Subsequently, but without morphological data, *riparia* has been recorded from: Terre Haute (Indiana), Franklin, Delaware and Licking counties (Ohio), Cape Girardeau, Perry and St. Louis counties (Missouri), Lincoln (Nebraska), and three localities in Arkansas.

In Oklahoma, worms of this species appear to be distinguishable (from those in Illinois) possibly by the additional segment covered by the clitellum (xix), by the segmental (postsetal) location of the genital markings, the absence of unpaired and median markings, the intestinal origin in xvii instead of xviii. This latter may be of some importance as one of the evolutionary developments in *Diplocardia* is posterior extension of the oesophagus. The elongation which may involve five or more segments probably takes place, as in other genera, by repeated single steps, a segment at a time. In Illinois where the intestinal origin is in xviii, evolution appears now to have proceeded one step further than in Oklahoma. An intestinal origin in xviii in one of the fifteen dissected Oklahoma worms may be attributable to a mutation for oesophageal extension.

No definite statement as to location of the last pair of hearts in this species has been found in the literature. However, Smith (1915, in a table opposite p. 554) did list hearts in xiii. That location was assumed to be correct in constructing the author's key to species (Gates, 1943), and on the same assumption the Oklahoma worms have been referred to *riparia*. As the character

is of considerable taxonomic importance confirmation from topotypical material, as well as for the specimens recorded from various other states, is desirable.

DIPLOCARDIA SANDERSI n. sp.

Dallas, Texas, 2/2/52, 1 clitellate specimen. Mr. Ottys Sanders.

External characteristics. Size, 135 x 7 mm. (strongly contracted). Segments, *ca.* 173. Secondary annulation; one secondary furrow on iv, two on each segment from v posteriorly. Pigmentation unrecognizable (lacking?, alcoholic preservation). Prostomium slightly epilobous, tongue closed. Setae mostly unrecognizable in the preclitellar region, posteriorly $AB < CD < BC < AA$, $DD \text{ ca.} = \frac{1}{2}C(?)$. Nephropores possibly slightly above *D* on clitellar segments and still more dorsally elsewhere(?). First dorsal pore on 10/11, a pore-like marking also present on 9/10. Clitellum annular, markedly tumescent, on xii/2-xix/2.

Sexthecal, spermathecal pores very small, at or close to *A* (slightly lateral?), slightly behind intersegmental furrows, on vii-ix. Seminal grooves on xviii-xx, concave laterally, in *AB*. Genital markings indistinct, paired, in *AB*, on 17/18 (?) and 20/21 (?)

Internal anatomy. Septum 5/6 with some muscularity, 6/7-10/11 thickly muscular, 11/12-13/14 muscular but decreasingly so posteriorly.

Gizzards in v-vi. Oesophagus considerably widened in xi-xv, deeply constricted at septal insertions and moniliform, with low, irregular and interrupted transverse ridges on inner wall, an uninterrupted longitudinal ridge—perhaps of slightly greater height—at mV. Oesophagus valvular in xvi-xvii. Intestinal origin in xviii. Typhlosole begins in xxiv, lamelliform, *ca.* 1.5 mm. high, behind lxxiii represented only by a low and rather irregular, strap-like thickening of the roof which ends in region of cxvii.

Dorsal trunk single throughout. Hearts of x-xiii apparently latero-oesophageal, those of xi-xiii (but not of x) traceable to ventral trunk. Segmental commissures between dorsal and ventral trunks, in the postclitellar portion of the body, are long

and considerably zig-zag-looped.

Nephridial funnels in *AB*, often within considerable clumps of coelomic corpuscles, not found on the tubules of *ii*. Nephridia extend well beyond *D*.

The brain is in *ii* and neither anterior nor posterior margin is incised. Absence of sheen on the nerve cord shows that any sheath is not especially muscular. Ganglionic swellings of the cord are very slight.

Holandric, seminal vesicles in *ix* and *xii*. (A testis sac or sacs possibly present ventrally in *x*.) Prostates in *xviii* and *xx-xxi*; ducts 2.5 mm. long, no special muscularity or sheen recognizable, ectal half straight, ental half in two small loops. Penial setae apparently lacking. A single vestigial follicle (?) deep in the musculature, somewhat median to the prostatic duct.

Ovaries and oviducal funnels, two pairs, in *xii-xiii*.

Spermathecae medium-sized, reaching well up alongside gut. Ampulla sausage-shaped, not much wider and somewhat shorter than the duct. The latter is not stout, somewhat narrowed ectally and especially within the parietes. Diverticulum a flattened and rather leaf-like ridge of seven or so seminal chambers, with a very short and slender stalk from the proximal edge near ental end passing to ental end of duct or slightly below. From a ventral portion of the diverticulum connective tissue passes to the septum in front. Discounting twisting, the diverticulum appears to be on the anterior face of the duct. Copulatory setae apparently lacking, no follicles protuberant from the parietes in *vii-x*.

Life history. The clitellum appears to be at maximal tumescence. Spermatozoal iridescence was not recognized on male funnels but was visible in the sticky contents of the spermathecal diverticula. The seminal vesicles showed no evidence of post-sexual regression. As the worm was obtained in February, the breeding season may be in the winter.

Remarks. The type had been preserved in a strongly contracted condition, in alcohol, and though not yet browned was becoming brittle when studied. Adherence of cuticle to parietes, even after several days in water, prevented recognition of some reproductive apertures and characteristics of the male field, possibly nephropores also. A deep longitudinal grooving at *mV*

in the clitellar region prevented recognition of female pores and any markings that may have been present there. Supra-oesophageal, subneural and extra-oesophageal trunks are quite unrecognizable. Nephridia are soft and fragment easily. Supposed ducts (blood vessels?) pass well beyond *D* and are without vesicular enlargement or are only slightly widened just as they pass into the parietes.

D. sandersi appears from its size and presence of hearts in xiii to be close to *D. longa* Moore 1904 (Pulaski County, Georgia) from which it is distinguishable as follows: location of gizzards (in v-vi rather than vi-vii); absence of a thick muscular sheath on the nerve cord; attachment of the spermathecal diverticulum to ental end of duct (rather than ectally); hologyny, and possibly by the absence of penial setae. The hologyny may, of course, be sporadic rather than specific. As *longa* is the only species of *Diplocardia* with the gizzards behind v-vi the difference in location now appears to justify specific status for the two taxa though the other differences may at present seem less important.

DIPLOCARDIA SINGULARIS (Ude) 1893?

Livingston County, Michigan, southwest woods, Edwin S. George Reserve, 1 juvenile and 1 acitellate anterior fragment, in poor condition. K. K. Bohnsack.

External characteristics. Sexthecal, spermathecal pores slightly lateral to *A*. Female pores probably in *AA*. Seminal grooves on xviii-xx.

Internal anatomy. Rather high longitudinal lamellae present on inner wall of prealvular portion of oesophagus. Intestinal origin in xvii. Dorsal blood vessel apparently single. Last hearts in xii.

Holandric, seminal vesicles in ix and xii. Spermathecal duct fairly long, erect in coelomic cavity, with muscular sheen though rather slender; diverticulum digitiform (?), attached to ental end of duct and directed ectally; spermathecal ampulla may be bent over and directed ectally on side of duct opposite diverticulum.

Remarks. This appears to be the first record of a *Diplocardia* from Michigan. Condition does not permit recognition of certain characteristics required for a specific identification. The nearest

sexthecal species geographically is *singularis*. Just how that species should be defined is not yet known though it has been reported from numerous localities in Ohio, Indiana, Illinois, Missouri, Arkansas and Louisiana.

DIPLOCARDIA sp.

Warner (25 miles southeast of Muskogee), Oklahoma, in Dirty Creek bottoms, April 1954, 1 small juvenile. Vera Lee Rounds.

External characteristics. Size, 40 x 1.5 mm. Segments, *ca.* 133. Pigmentation quite unrecognizable throughout (formalin preservation). First dorsal pore on 9/10. Ventral setae of xviii-xx unrecognizable but seminal grooves lacking. Spermathecal pores probably on anterior margins of viii-ix, at or just lateral to A.

Internal anatomy. Septum 6/7 is muscular, 7/8-8/9 somewhat thicker. Gizzards in v-vi. No special calciferous lamellae on inner wall of prealvular portion of oesophagus. Intestinal origin in xvii. Typhlosole begins in xx and is definitely lamelliform though not large. Dorsal blood vessel single throughout. No subneural. Last hearts in xii.

Holandric (?), seminal vesicles recognized only in xii. Penisetal follicles much longer than the prostatic duct, apparently passing separately into parietes median to prostates of xviii and xx. Penial setae 1.1-1.3 mm. long, 10-15 μ thick. Tip flattened on two sides, tapering to a very short filament which may be bent or curved to one side. One mature and at least one very short reserve seta in each follicle, two extra reserves in one follicle.

Ovaries are much larger than in the smallest juvenile of *riparia* (from the same batch).^{*} Spermathecae, juvenile, pass into parietes at A, anteriorly in viii-ix, diverticula unrecognizable.

Remarks. This worm probably would have attained sexual maturity at a much smaller size than does *riparia*. Ventral setae of viii-x may be copulatory. The follicles projected slightly into the coelomic cavities but attempts to remove the setae were unsuccessful.

This form runs down in the author's key (Gates, 1942, p. 92) to *D. udei*. The latter has been known hitherto only from descriptions of the types secured at Raleigh, North Carolina. A

doubtful record from Terre Haute, Indiana, never has been confirmed. The Oklahoma worm apparently is distinguishable by location of the spermathecal pores, absence of gut widening in xv and of high calciferous lamellae therein, simplex condition of the dorsal blood vessel posteriorly, and by the terminal filament of the penial setae. Additional differences may be recognizable at maturity.

DIPLOCARDIA UDEI Eisen 1899

Highlands, North Carolina. In soil under moss by stream on path to Primeval Forest (altitude *ca.* 3,900 ft.), July 24, 1931, 1 clitellate specimen. In pocket of sandy black soil (pH 5.0) under dead leaves by stream in forest on path to Primeval Forest, July 27, 1931, 2 early juvenile, 1 a clitellate and 18 clitellate specimens. Virgin Forest, August 20, 1932, 4 early juvenile, 1 late juvenile, 2 a clitellate and 8 clitellate specimens. J. M. Valentine per Dr. G. E. Pickford.

External characteristics. Length, 90-120 mm. (clitellate specimens, not strongly contracted). Diameter, 3-3½ mm. (through clitellum or gizzard region which is the thickest portion of the body). Segments, 159, 166 (posterior amputee), 177, 178, 179, 180, 181. Secondary annulation fairly distinct, a presetal and a postsetal furrow present from v or vi, a tertiary furrow on the first and last secondary annuli of vii-viii and occasionally on one or more additional segments. Pigmentation unrecognizable and probably lacking (formalin preservation). Prostomium, indeterminate (6), possibly epilobous and with open tongue (3), apparently tanylobous (28) with a longitudinal furrow at mD from 1/2 well out onto prostomium (23), with an additional furrow on each side of the tongue (7), with only two longitudinal furrows on the tongue and neither median (5). Setae begin on ii on which all are present; *AB ca.* = or very slightly < *CD < BC < AA*, *DD ca.* = ½C, not closely paired, ventral setae of viii-ix copulatory, of xviii and xx penial, of xix lacking. Nephropores unrecognizable but possibly on most segments at *D*, probable sites sometimes indicated by slight tumescences. First dorsal pore on 9/10 (1), 10/11 (28), 11/12 (5), not determinable (3, not certainly recognizable anterior to clitellum). Clitellum dark red, annular except on xviii, usually more or less tumescent but

intersegmental furrows and setae present though dorsal pores are occluded, on xiv-xvii with slight reddening of pq/xiii and aq/xviii (3, of which one certainly and another probably in early sexual stage), on xiii-xviii (24), epidermal thickening gradually decreasing in xviii and usually slight or unrecognizable behind the equator though the red coloration is continued to 18/19.

Spermathecal pores minute, on or slightly lateral to *A*, in front of or on the presetal secondary furrows of viii-ix and at least half way towards the equators. Female pores apparently always paired and anteromedian to *a*, (sites obvious though definite apertures recognizable only on 5 specimens). Male and prostatic pores unrecognizable. A male field is not marked off and the region between the seminal grooves is not depressed. Grooves sinuous, in *AB*, between equators of xviii and xx, the margins of the grooves tumescent.

Genital markings transversely elliptical, with greyish translucent, circular centers, in a longitudinal row of 4-7 immediately lateral to each seminal groove, one to three markings on each of xviii-xx, occasionally crossing intersegmental furrows.

Internal anatomy. Septa 5/6-6/7 membranous (streaks of sheen sometimes visible in 6/7), funnel-shaped and must be peeled back from the gizzards to discover insertions on gut; 7/8 slightly muscular, 8/9-9/10 muscular or 7/8-13/14 slightly muscular to muscular.

Gizzards rather large, in v-vi (36). Oesophagus quite obviously widened in xv (36) and with fairly high, thin, white, lamelliform longitudinal ridges some of which are continued but at lower height into xvi where they are continuous with ridges of the valve or forwards even into x. The portion of the gut in xvi may have the same external appearance as the segment in xv or xvii. The valve is short and extends slightly into xvi and xvii (36). Intestinal origin in xvii (36), gut highly vascularized in xvii, less so in xviii-xix. The typhlosole begins in xix (35) or xx (1) but may project slightly into xviii or xix and is nearly one mm. high, lamelliform, height abruptly decreasing in liv and unrecognizable behind lvi (1) or ending in lx (1) but with a flat ribbon-like thickening still recognizable at mD through several further segments (worm with 177 segments).

Dorsal blood vessel single anteriorly, doubled posteriorly (36)

and in cxxi-clxxvii (1) or in the last 66 segments (2 specimens), 60 (2), 59 (1), 56 (1), 46 (1), 40 (1), 36 (1). The doubled portion is short, midsegmental, often easily recognizable because of presence of a bit of chlorogogen in the perforation. The perforation may be lacking (no doubling?) in any particular segment, in two, three or even several consecutive metameres. A quite obvious perforation is present in xlvi of a worm in which doubling was otherwise lacking except in the last 56 segments. Supra-oesophageal trunk adherent to the gut and recognizable only in ix-xii, usually empty. Extra-oesophageals recognizable only in v-vii where they are distended with blood. Subneural trunk lacking (36). A latero-oesophageal vessel in *BC* is recognizable only in ix-xx and may also be doubled. Into these vessels in xiv-xx the segmental branches from the dorsal trunk (long, looped and with chlorogogen) apparently pass. Hearts of x-xii apparently latero-oesophageal but both dorsal bifurcations are filamentous and without blood. Hearts of ix lateral. Last hearts in xii (36 specimens).

Nephridia are present from ii posteriorly and are small, behind the clitellum reaching slightly lateral to *D*, apparently avesciculate. The ducts (?) pass into the parietes at or near *D*.

The brain apparently is in iii, near level of intersegmental furrow $3/4$ (17) but septa are unrecognizable dorsally. The posterior margin is very slightly concave. The nerve cord is without marked muscularity of the sheath.

Holandric, seminal vesicles in ix and xii (33, unrecognizable in 3 juveniles), acinous. Vasa deferentia of a side come into contact in xiii or behind $13/14$ but do not unite until just before they pass down into the musculature just behind $18/19$, occasionally crossing over each other. Prostates, in xviii or xviii-xix and xx or xx-xxi (once one prostate in xx-xix), small, straight or in one or two u-shaped loops. Ducts slender, white, nearly straight or ental portion with one or two loops, $1-1\frac{1}{2}$ mm. long.

Ovaries fairly large, fan-shaped, with long strings of eggs. Oviducts not enlarged, gradually narrowed from the funnel ectally.

Spermathecae medium-sized, usually long enough to reach up to level of dorsal face of gut. Ampulla rather sausage-shaped to ovoidal but not clearly delimited externally from and only

slightly thicker than the duct. The latter is not stout and is slightly narrowed ectally, especially within the body wall. The diverticulum may be a vertical row of 3-7 rounded lobes on the lateral side of the duct with a short stalk from near the upper end or more flattened, fan-shaped and stalkless but also vertical. Occasionally with more than 7 seminal chambers and rather berry-shaped but still vertical. Diverticulum-duct junction always well above the parietes and in many cases apparently near ental end of duct. Connective tissue from diverticulum to septum in front delicate and usually only a slight filament.

Follicles of the copulatory setae, always present in viii-ix (36), project into the coelomic cavities (but not in x or vii) and are united entally with a muscular strand passing laterally to the parietes. Reserves may be present in the coelomic portions of the follicles. The tip of the setal shaft is shortly claw-shaped. Ornamentation, ental to the claw, is of narrow, open, longitudinally placed excavations each of which usually is continued entally into a small pocket of which the outer wall is very thin. Excavations may be so closely crowded that intervening regions have a meshwork appearance in a strictly surface view. The wall of a pocket at sides of shaft, in appropriate optical section, has an appearance of a large, ectally directed triangular tooth or scale. Reserves are red, functional setae yellowish or greenish.

Follicles of the penial setae reach to or well towards the middle of the prostatic duct and are continuous entally with a muscular strand just in front of the septum and inserted into parietes just lateral to *D*. The *b* follicle passes into the body wall on the anterior face of the prostatic duct in the *b* gap and the other follicle into the *a* gap. Shafts are one mm. long, slender and yellowish, slightly arced or with a more marked curvature ectally. The tip narrows gradually but instead of coming to a point is slightly flattened, widened and with a single concavity in the ectal margin. This very small terminal portion, usually lacking, may have an appearance of two very small rounded lobes. Ornamentation is sparse, of very small spines, few and isolated or in several circles. Reserve setae were not recognized.

A small, low mound of soft material, presumably glandular, is present on the parietes in xviii and xx median to the prostatic duct. No glandular material is however recognizable on or in

the body wall immediately beneath the genital markings.

Juveniles. The *a* and *b* setae in xviii and xx are only slightly approximated in the smaller juveniles, those of xix still in line with the same setae of other segments. Ventral setae of xviii and xx are unrecognizable externally on the larger juveniles though in xix they may still be protuberant and normally located. In one late juvenile only one *b* seta is still visible (in normal location) on xix, apertures of other ventral follicles occluded. In this worm there is on each side a slight, almost straight, longitudinal tumescence between the equators of xviii and xx exactly in *AB* and with a slight groove representing the seminal furrow. Genital markings had not appeared. Penisetal follicles in juveniles may reach well towards or even to ental end of prostates.

Abnormality. No. 1. Spiral metamerism near tail end involving three segments. No. 2. Left spermatheca of viii twice length of others. Only a short ental portion slightly widened like an ampulla. Diverticulum (no iridescence) at normal distance from parietes.

Life history. Coelomic cavities of x-xi are packed full of coagulum in each acelitellate and clitellate worm. The vasa deferentia are iridescent in 26 of the clitellate specimens. Spermathecal diverticula have a marked iridescence in 24 and male funnels of 19 have a similar spermatozoal iridescence. Each spermathecal ampulla is occupied by a hard, pink, translucent mass. Reproduction obviously is sexual (biparental) and ovaries usually appear to be mature. Cocoon deposition in July-August may be expected in the Highlands locality if there is adequate moisture.

Regeneration. None. Only one amputee (posterior).

Remarks. In a four foot square area in which the soil above the rock was only one foot deep there were 45 earthworms (including other species).

The worms apparently had been preserved in a relaxed condition admirably suited for determination of location of first dorsal pore. The pores are wide open and in a posterior portion of the soma the dorsal vessel occasionally is protuberant through the openings. The peristomium is however longitudinally furrowed all around and as a result of this wrinkling (?) little importance can be attached to the tanylobous characterization of the pro-

stomium. Genital markings which might have been more difficult of recognition in strong contraction are quite obvious. Recognition of female, male and prostatic pores was no easier than when worms are contracted.

Highlands material differs from the Raleigh types as follows: fewer segments (to 181 instead of 200-220), tanylobous prostomium (instead of epilobous), location of spermathecal pores on or close to *A* (instead of in front of *b*), paired female pores (instead of 1?), extramural spermathecal diverticulum (hidden in wall and perceptible only in sections), and possibly by absence of copulatory setae in *x*. Genital markings appear to be different. The types may have been less mature than the Highlands worms and preservation may well have been different. For the present then there is no good contraindication to identification as *udei*.

D. udei is more advanced than *D. gracilis* Gates 1943 with respect to development of calciferous lamellae but less advanced with respect to posterior dislocation of spermathecal pores and posterior extension of the oesophagus. *D. gracilis* is however known only from the holotype from somewhere in Tennessee.

DISCUSSION

The genus *Diplocardia*, restricted to the United States and Mexico, is especially interesting because of the marked variation shown in characteristics often uniform throughout a genus or whole groups of genera. Within this genus the oesophagus has been elongated to various levels, intramural calciferous glands occasionally have been closed off, an intestinal typhlosole has been developed sometimes to a stage of ventral bifurcation, the dorsal blood vessel often has been doubled either in one portion or throughout almost all of the soma, penial and copulatory setae have been developed, the spermathecae have been shifted about variously, and the male terminalia—without modification of the ancient quadriprostatic and three-segment pattern—have been translocated posteriorly one, two or even three metameres. Four seminal vesicles, in *ix-x* or *x-xi*, presumably have been eliminated. Intrageneric acquisitions also include: a brown pigment, an extra pair of spermathecae (in *vii*), and an extra pair of hearts (in *xiii*). Gizzards apparently have been shifted back one segment in a species in which the nerve cord sheath has be-

come thickly muscularized. Except in the excretory system which still remains to be studied, all of the major anatomical changes that have been made in this genus may have been recognized.

Little however is known about any particular species. The diplocardias must have been common in Texas prior to the introduction of various European and Asiatic exotics. In spite of the competition with much more adaptable species to which the diplocardias have been exposed they may still be fairly common in that state (p. 236). Nevertheless, for the whole of Texas, records have been found of the identification of only three specimens. Larger numbers of identifications have been reported for each of several other states but often (5 states) without descriptions or even any records as to variation. Early descriptions of various species, now inadequate, still have to be corrected and supplemented, preferably from topotypical material in longer series than were originally available or utilized. Nor is there much more certainty now than previously (Gates, 1943) as to just what characteristics, or combinations of them, warrant specific status.

The material of the present as well as of the previous contribution (1943) already has provided instances of individual variation in some of the characteristics by which species have been distinguished and defined. Furthermore, the constant necessity for mention of differences from material previously examined (cf. *ornata* from Tennessee and Oklahoma, *udei* from Raleigh and the mountains of western North Carolina, *communis* from North Carolina and Illinois, etc., on previous pages, and also Eisen, 1900, Heimburger, 1915) is at least suggestive of geographical variation. Further detailed studies can be expected to obviate unnecessary erection of new species and enable suppression of some species or reduction to subspecific status. Thus, for instance, *D. singularis*, *caroliniana* Eisen 1899 and *ornata* seem to be variations on a common theme and other instances of similar sort could be cited.

Doubling of the dorsal blood vessel, as already noted, begins at or close to the anterior end or only towards the anal region. In the former case the doubling may be continued through the clitellar region only (*alba*), somewhat more posteriorly (*fusca*)

or even to the hind end of the body (*communis*). When the duplicity is only posterior there also may be considerable variation in the size of the region involved. Genetic determiners for this major evolutionary change presumably prevent mid-dorsal fusion of paired embryonic anlage except in regions of septal insertions and evidently become operative at various stages of development. In species such as *fusca* these determiners become ineffective rather early in embryonic growth.

The diplocardias, once common in southern Illinois, were thought years ago (cf. Smith, 1928) to be disappearing in competition with the exotics which have been increasingly distributed ever since, both accidentally and deliberately (Gates, 1954), throughout much of this country. If these peregrine forms are as successfully competitive as Smith, and indeed others, thought it may already be too late for conservation of some important races even in museum alcohol. In Texas, and presumably also certain other parts of the generic range, there still seems to be an opportunity to learn much about the evolution of this American genus.

SUMMARY

Material of *D. alba mexicana* n. subsp., *communis* (from North Carolina), *invecta* n. sp. (Mexico), *ornata* (Arkansas), *riparia* (Oklahoma), *sandersi*, n. sp. (Texas), *udei* (mountains of western North Carolina), as well as the first elitellate specimen of the large Texan *fusca*, is described, with data on variation and notes on abnormality, life history, regeneration, habitats and habits. Successful colonization after accidental transportation may have taken place within or near the proper generic range but is not expected elsewhere. Little is known about any species but major intrageneric evolutionary changes in anatomy probably have been recognized and are listed. Considerable geographic variation seems to be indicated by the data now available. Genetic determiners for doubling of the dorsal blood vessel become operative at different stages of development but in some species become ineffective rather early. Although diplocardias long may have been disappearing in areas affected by intensive cultivation or other human activity, less disturbed regions apparently still may provide opportunities for study of a genus restricted to the United States and Mexico.

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